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UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.
P-1592-US1
Total Pages in this Submission
46

TO THE ASSISTANT COMMISSIONER FOR PATENTS

Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS

jc675 U.S. PTO 09/493004 01/28/00

and invented by:

Daniel Yellin

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

☒ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: **09/103,683**

Which is a:

☐ **Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: ______

Which is a:

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below

2. ☒ Specification having **28** pages and including the following:

   a. ☒ Descriptive Title of the Invention

   b. ☐ Cross References to Related Applications *(if applicable)*

   c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*

   d. ☐ Reference to Microfiche Appendix *(if applicable)*

   e. ☒ Background of the Invention

   f. ☒ Brief Summary of the Invention

   g. ☒ Brief Description of the Drawings *(if drawings filed)*

   h. ☒ Detailed Description

   i. ☒ Claim(s) as Classified Below

   j. ☒ Abstract of the Disclosure

Postcard

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☒ Formal Number of Sheets 5
   b. ☐ Informal Number of Sheets ______
4. ☒ Oath or Declaration
   a. ☐ Newly executed *(original or copy)* ☒ Unexecuted
   b. ☒ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☒ With Power of Attorney ☐ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☒ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ Computer Program in Microfiche *(Appendix)*
7. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   a. ☐ Paper Copy
   b. ☐ Computer Readable Copy *(identical to computer copy)*
   c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

8. ☒ Assignment Papers . (copy from prior application)
9. ☐ 37 CFR 3.73(B) Statement *(when there is an assignee)*
10. ☐ English Translation Document *(if applicable)*
11. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations
12. ☒ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☐ Certificate of Mailing
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UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)	Docket No. P-1592-US1
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Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) *(if foreign priority is claimed)*

16. ☐ Additional Enclosures *(please identify below)*:

Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra		Rate	Fee
Total Claims	27	- 20 =	7	x	$18.00	$126.00
Indep. Claims	4	- 3 =	1	x	$78.00	$78.00
Multiple Dependent Claims (check if applicable) ☒						$260.00
					BASIC FEE	$690.00
OTHER FEE *(specify purpose)*						$0.00
					TOTAL FILING FEE	$1,154.00

☐ A check in the amount of to cover the filing fee is enclosed.

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Signature

Dated: **01/28/00**

cc:

S/N:UNKNOWN **PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Daniel YELLIN Examiner: To be Assigned

Serial No.: To be Assigned Group Art Unit: To be Assigned

Filed: Herewith Attorney Docket No: P-1592-US1

Title: METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS

CERTIFICATE UNDER 37 CFR 1.8
I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, DC 20231,
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PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

Please amend the Patent application before examination, as follows:

In the Specification:

After the Title, please add --CROSS-REFERENCE TO RELATED APPLICATIONS. This application is a continuation of allowed U.S. Patent Application Serial No. 09/103,683 filed June 15, 1998, which is incorporated herein by reference.--

REMARKS

Entry of this Preliminary Amendment prior to Examination of the instant patent application is respectfully requested. The amendments do not add new matter to the application.

If there is any question or comment as to the form, content, or entry of this paper, the Examiner is requested to telephone the undersigned counsel at the address and telephone number listed below. If there are any further issues to be resolved to advance the prosecution of the is application to issue, the Examiner is requested to telephone the undersigned counsel.

Prompt consideration and allowance of the claims is respectfully requested.

Respectfully submitted,

Daniel YELLIN
By his Attorneys

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METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS

Danny YELLIN

FIELD OF THE INVENTION

The present invention relates to a method and a device for quantizing the input to a soft decoder and to a method and a device for quantizing the input to a Viterbi decoder, operating over fading channels, in particular.

BACKGROUND OF THE INVENTION

The classical problem of quantizing an analog signal into some set of a-priori chosen discrete-alphabet values, was extensively studied following the pioneering work of Shannon on rate distortion theory published in 1948 by C.E. Shannon, "A mathematical theory of communication" Bell System Technical Journal, 27, 1948.

Various quantization methods are known to those skilled in the art. In general, each of these methods utilizes a specific cost function. The object of a quantizer is to minimize the respective quantization cost.

In digital communication applications, digital information is modulated onto a carrier signal which is then, transmitted over an analog channel. The output of the channel is sampled, quantized and processed by the receiver in order to recover the transmitted digital information.

The natural cost function which is used in this case is the probability of error. The objective of the quantization strategy is to minimize the probability of incorrectly receiving the transmitted information.

Unfortunately, analytically minimizing this cost function is mathematically intractable even for relatively simple scenarios (see e.g. Salz and Zehavi). Accordingly, ad-hock solutions are often used.

Reference is now made to Fig. 1, which is a schematic illustration of a digital communication receiver, generally referenced 10, known in the art.

System 10 includes an analog to digital (A/D) converter 12, a demodulator 14, an automatic-gain-control (AGC) unit 15, a quantizer 16, and a decoder 18.

The transmitted signal is picked-up by the receiver's antenna and is then amplified and filtered at the receiver's front-end (not shown in Fig. 1). The resulting signal is fed into system 10 at the input of the A/D 12.

The A/D 12 converts the signal to digital samples and provides them to the demodulator 14. The demodulator 14 processes the digitized samples and produces a demodulated signal $Y[n]$. The AGC unit 15 normalizes the demodulated signal $Y[n]$, to fit into the dynamic range of the quantizer 16, as follows

$$\tilde{Y}[n] = AGC\_Gain \cdot Y[n]$$

Equation 1

where AGC_Gain may vary from sample to sample.

The quantizer 16 processes the normalized samples $\tilde{Y}[n]$, thereby producing the quantized samples $Q(\tilde{Y}[n])$ such that each sample is represented by B bits. In most cases, $Q(\tilde{Y}[n])$ is simply the nearest element to $\tilde{Y}[n]$ in the set of 2^B possible quantization levels. The quantized samples are provided to the decoder 17, which in turn attempts to recover the transmitted information.

It is noted that system 10 is a mere example to systems which are known in the art. Those skilled in the art are familiar with several other

configurations. For example, in a spread-spectrum CDMA (Code Division Multiple Access) environment operating on a multi-path fading channel, the demodulator is replaced by a rake demodulator. A rake demodulator includes a plurality of demodulating fingers, each of which attempts to detect and demodulate a different replica of the transmitted signal.

According to another example, an analog demodulator may be utilized. In this case, an A/D converter is placed after the demodulator, sometimes also serving as a quantizer.

However, regardless of the specific receiver type and structure, its complexity, or more particularly, the complexity of the decoder, increases with B - the number of bits used to represent each quantized sample $Q(\widetilde{Y}[n])$. Therefore, it is desirable to chose a quantization strategy that minimizes B.

The minimal possible value for B is $B=1$, which is called "Hard Decision". In this case the numbers produced by the quantizer are restricted to have only two possible values "one" and "zero". All other situations are called "Soft Decision" and correspond to the case where $B>1$.

When hard-decision is used, only the sign of $\widetilde{Y}[n]$ is fed into the decoder, thus completely ignoring any information conveyed by its magnitude. Therefore, hard-decision decoding, although very simple to implement, can lead to a significant degradation in performance.

On the other hand, when B is very large, the full potential of the code is utilized. It will be noted however, that in this case, the decoder complexity is high. It is therefore desirable to come-up with an efficient quantization strategy that allows good tradeoff between decoder complexity and quantization loss.

Methods for quantizing the input to a soft decoder operating over a static AWGN channel are described in Onyszchuk et. al. In this case, the demodulated signal can be represented by

$$Y[n] = h \cdot S[n] + W[n]$$

Equation 2

where $S[n]$ is the desired (information bearing) signal that needs to be decoded, h is the complex valued channel gain, and $W[n]$ is an additive white Gaussian noise term.

The conventional quantization strategy for such channels is based on first normalizing the RMS (Root Mean Square) value of $Y[n]$ to a pre-determined value denoted by Desired_RMS, and then applying a uniform quantizer e.g. a conventional A/D converter. The normalization operation is performed by the AGC according to Equation 1, by setting

$$AGC\_Gain = \frac{Desired\_RMS}{Estimated\_RMS}$$

Equation 3

where the Estimated_RMS may be computed in a variety of ways, e.g.

$$Estimad\_RMS = \sqrt{\frac{1}{N} \cdot \sum_{n=1}^{N} |Y[n]|^2}$$

Equation 4

This quantization strategy performs well when the channel is static, (i.e. the model in Equation 2 holds).

However, when implemented for non-static channels, this approach can lead to a significant degradation in performance. In order to clarify this, we now consider a simple generalization of Equation 2, in which

$$Y[n] = h[n] \cdot S[n] + W[n]$$

Equation 5

where, as before, $Y[n]$ is the demodulated signal; $S[n]$ is the information bearing signal; $W[n]$ is the additive white Gaussian noise term; and $h[n]$ is the complex valued channel gain which is now allowed to be time varying.

Reference is now made to Figs. 2A, 2B, 2C and 2D.

Fig. 2A is an illustration of a frame of a transmitted signal, generally referenced 140A. The signal is divided into a plurality of sections 150A, 152A, 154A, 156A, 158A and 160A, each including a plurality of symbols represented by dots. For example, section 150A includes five symbols. The first three symbols and the fifth symbol, are of a value of +1, while the fourth symbol is of a value of -1.

Fig. 2B is an illustration of a dynamically fading channel where we plotted only its magnitude $|h[n]|$, generally referenced 142. Each of the dots along the line represents the gain of the channel at a point in time which is respective to a symbol of signal 140A (Fig. 2A).

Fig. 2C is an illustration of the demodulated signal $Y[n]$ of the received frame in the absence of noise according to the simple model of Equation 5, generally referenced 140B. Each of the samples in the demodulated signal 140B is, in general, a multiplication of a selected transmitted symbol of signal 140A (Fig. 2A) and the respective fading value of the channel 142 (Fig. 2B).

Fig. 2D is an illustration of the quantized signal $Q(\tilde{Y}[n])$, produced from signal 140B, when AGC_Gain is set to unity and the following five level uniform quantizer utilized,

$$Q(\tilde{Y}[n]) = \begin{cases} 1 & \text{if} \quad \tilde{Y}[n] > 0.75 \\ 0.5 & \text{if} \quad 0.75 \geq \tilde{Y}[n] > 0.25 \\ 0 & \text{if} \quad 0.25 \geq \tilde{Y}[n] > -0.25 \\ -0.5 & \text{if} \quad -0.25 \geq \tilde{Y}[n] > -0.75 \\ -1 & \text{if} \quad \tilde{Y}[n] \leq -0.75 \end{cases}$$

Equation 6

As can be seen from Equation 5, Equation 6 and Fig 2D, all samples for which the fade magnitude is smaller than 0.25, such as the samples in section 158B (Fig. 2C), are mapped by the quantizer to the value "0" (section 158C).

These are called erasures, since they contain no information on the actual transmitted bit – it can equally likely be a "1" or a "-1".

It will be appreciated by those skilled in the art (see for example: G.C. Clark Jr and J. Bibb Cain "Error - Correction Coding for Digital Communications" Chapter 5) that if the number of erasures is larger than a certain threshold related to the minimum distance of the code, then even an optimal decoder is likely to be in error.

Thus, whenever a deep channel fade occur for a sufficiently long period, a decoding error will occur due to the quantization of the sampled data during the fade into erasures. This phenomenon happens regardless of the specific decoding method and/or decoding structure. Furthermore, even if erasures do not occur, decoding errors are still most likely to occur during channel fades, since the SNR (Signal-to-Noise Ratio) is low in these periods.

It is therefore clear that in a fading environment it is the quantization of the samples corresponding to low channel gain that attribute the most to the quantization loss.

One simple way to reduce the quantization loss is by using a larger value of Desired_RMS in Equation 3. With this approach, the signal is amplified so that its low magnitude portion is better mapped on the dynamic range of the quantizer. The price is of course worsening the mapping of the large magnitude portion of the signal that leads to clipping effects. Such clipping have a negligible affect on the overall performance, since they occur when the SNR is relatively high. Thus, overall an

improvement in performance is achieved. However, if the channel happens to be static, the Desired_RMS value will no longer correspond to its optimal value resulting in an increase in quantization loss. Furthermore, even with fading channels, different Desired_RMS values are required for different fading characteristics. The approach presented below circumvents these issues.

SUMMARY OF THE PRESENT INVENTION

It is an object of the present invention to provide a novel system for quantizing the input signal for a soft decoder, operating over fading channels, which overcomes the disadvantages of the prior art.

In particular, it is the object of the present invention to provide a method for quantizing an input signal for a soft viterbi decoder, operating over fading channels, which overcomes the disadvantages of the prior art.

In accordance with one aspect of the present invention, there is thus provided a method for processing a received signal, which is received from a dynamically fading channel. The method includes the steps of:

detecting the fading characteristics of the fading channel, and

determining a quantization correction command for at least one segment of the received signal.

The method can also include the step of quantizing the analyzed segment, according to the quantization correction command, thereby producing a quantized signal which is followed by a step of decoding the quantized signal.

The step of decoding the quantized signal can be performed while taking into account the quantization correction command associated with the decoded segment.

The method according to the invention, can also include the step of demodulating the received signal, either before or after the step of quantizing.

In accordance with another aspect of the present invention, the step of detecting includes the sub-steps of estimating the RMS of the received signal and computing the minimal and maximal quantities of the samples of the received signal.

In addition, the step of determining can include the sub-step of estimating a preferred RMS value.

The method can also include the step of normalizing the received signal according to the preferred RMS value.

The step of detecting can include the following sub-steps of estimating the RMS of the received signal, thereby producing an Estimated_RMS value, and estimating channel tap values $\hat{h}[n]$ from the received signal. The step of determining includes the following sub-steps of calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv |\mathrm{Re}\,al\{\hat{h}[n]\}| + |\mathrm{Im}\,ag\{\hat{h}[n]\}|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and determining a desired_RMS_fade value from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

Furthermore, the method of the invention, can also include the step of normalizing the samples, wherein the step of normalizing is performed according to the following expression:

$$\tilde{Y}[n] = \frac{Desired\_RMS\_Fade}{Estimated\_RMS} \cdot Y[n]$$

wherein $Y[n]$ denotes a pre-quantized value of a selected sample and $\tilde{Y}[n]$ denotes a normalized pre-quantized value of the selected sample.

The desired_RMS_fade value can be determined from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$ according to a look-up table having $\Theta_{\max} - \Theta_{\min}$ at its input and Desired_RMS_Fade at its output.

In accordance with a further aspect of the present invention, there is thus provided a quantizing device for installing in a receiver. The receiver further includes a signal reception unit, a demodulator and a decoder. The receiver receives a signal from a dynamically fading channel wherein the demodulator demodulates the received signal thereby producing demodulated signal.

The quantizing device includes, a channel fading detection unit, connected to the signal reception unit, for detecting the fading characteristics of the dynamically fading channel, a processor, connected to the channel fading detection unit, for processing the fading characteristics, thereby producing a correction command for at least one segment of the received signal and a quantizing unit connected to the processor, the demodulator and the decoder, for quantizing the demodulated signal, thereby producing a quantized signal.

The quantizing unit also corrects the segment according to the correction command and the decoder decodes the quantized signal.

The processor can further provide the correction command to the decoder and thus, the decoder decodes the quantized signal according to the correction command.

The processor determines the correction command by calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv |\mathrm{Re}al\{\hat{h}[n]\}| + |\mathrm{Im}ag\{\hat{h}[n]\}|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and subsequently determining a desired_RMS_fade value from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

The desired_RMS_fade value is determined from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$ according to a look-up table having $\Theta_{\max} - \Theta_{\min}$ at its input and Desired_RMS_Fade at its output.

In accordance with yet another aspect of the present invention, there is thus provided a fading compensation device including for installing in a receiver. Such a receiver includes a signal reception unit, a demodulator, a quantizing unit and a decoder. The receiver receives a signal from a dynamically fading channel. The demodulator demodulates the received signal thereby producing a demodulated signal.

The fading compensation device includes a channel fading detection unit, connected to the signal reception unit, for detecting the fading characteristics of the dynamically fading channel, a processor,

connected to the channel fading detection unit, for processing the fading characteristics, thereby producing a correction command for at least one segment of the received signal and a correction unit, connected to the processor, the demodulator and the quantizing unit, for correcting the demodulated segment corresponding to the segment according to the correction command, thereby producing a corrected segment.

The correction unit replaces the demodulated segment with the corrected segment at the input of the quantizing unit.

The processor determines the correction command by calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv \left|\mathrm{Re}al\{\hat{h}[n]\}\right| + \left|\mathrm{Im}ag\{\hat{h}[n]\}\right|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and subsequently determining a desired_RMS_fade value from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

As described above, the desired_RMS_fade value is determined from the $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$ according to a look-up table having $\Theta_{\max} - \Theta_{\min}$ at its input and Desired_RMS_Fade at its output.

According to another aspect of the invention, the processor is further connected to the decoder, thereby providing the correction command to the decoder for decoding the quantized representation of the corrected segment, with respect to the correction command.

In accordance with a further aspect of the present invention, there is thus provided a receiver which includes a signal reception unit, for receiving a signal from a dynamically fading channel, a demodulator, connected to the signal reception unit, for demodulating the received signal, thereby producing a demodulated signal therefrom, a quantizing processor, connected to the demodulator and to the signal reception unit, for analyzing the received signal and for quantizing the demodulated signal, thereby producing a quantized signal and a decoder, connected to the quantizing processor, for decoding the quantized signal.

The quantizing processor normalizes the demodulated signal according to the estimated fading of the received signal.

It will be noted that the received signal can be, for example, a DS-CDMA signal and wherein the demodulator is a rake receiver, and the like. Accordingly, the quantizing processor analyzes the received signal by summing the channel taps of selected fingers.

It will further be noted that the decoder can be a Viterbi decoder and the like.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the drawings in which:

Fig. 1 is a schematic illustration of a signal decoding system, which is known in the art;

Fig. 2A is an illustration of a frame of a transmitted signal;

Fig. 2B is an illustration of a dynamically fading channel;

Fig. 2C is an illustration of a frame of a received signal, after traveling through the fading channel of Fig. 2B;

Fig. 2D is an illustration of a quantized frame, produced from the frame of received signal of Fig. 2C;

Fig. 3 is a schematic illustration of a receiver, constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 4 is a schematic illustration of a method for operating the receiver of Fig. 3, operative in accordance with a preferred embodiment of the present invention;

Fig. 5 is a schematic illustration of a receiver, constructed and operative in accordance with another preferred embodiment of the present invention; and

Fig. 6 is a schematic illustration of a receiver, in which there is installed a quantizer, constructed and operative in accordance with a further preferred embodiment of the present invention; and

Fig. 7 is a schematic illustration of a receiver, constructed and operative in accordance with another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention overcomes the disadvantages of the prior art by providing a novel method which dynamically detects the characteristics of the transmission channel, and accordingly quantizes the received signal into a pre-selected set of alphabet values.

The method according to the present invention, estimates the dynamics of the transmission channel within the received frame, and accordingly provides the quantization strategy.

Reference is now made to Fig. 5, which is a schematic illustration of a method, operative in accordance with a preferred embodiment of the present invention. The quantizer operates on blocks of N samples. Each of these blocks is processed according to the following steps:

In step 250, the RMS of the received signal is estimated, e.g. according to Equation 4.

In step 252, the quantities $\Theta_{\min}$ and $\Theta_{\max}$ are computed, where:

$$\Theta_{\max} \equiv Max_n\{\Theta[n]\} \quad \text{and} \quad \Theta_{\min} \equiv Min_n\{\Theta[n]\}$$

Equation 7

for $1 \le n \le N$, and $\Theta[n]$ is given by

$$\Theta[n] \equiv \left|\mathrm{Re}\,al\{\hat{h}[n]\}\right| + \left|\mathrm{Im}\,ag\{\hat{h}[n]\}\right|$$

Equation 8

where $\hat{h}[n]$ denotes an estimate of the channel tap value $h[n]$.

In step 254, the Desired_RMS value is determined by

$$Desired\_RMS\_Fade = F(\Theta_{\min}, \Theta_{\max})$$

Equation 9

where F(,) is some function whose purpose is to have Desired_RMS_Fade equal to the Desired_RMS value used for static

channels whenever Θ_{min} and Θ_{max} are close, and to increase the Desired_RMS value when Θ_{min} and Θ_{max} differ.

In step 256, the received samples are normalized according to

$$\tilde{Y}[n] = \frac{Desired\_RMS\_Fade}{Estimated\_RMS} \cdot Y[n]$$

Equation 10

In step 258, the normalized samples are quantized by setting $Q(\tilde{Y}[n])$ as the closest value to $\tilde{Y}[n]$ in the pre-determined quantizer alphabet.

It will be noted that for static channels (Ignoring estimation errors) $\Theta_{min} = \Theta_{max}$. Therefore, the above procedure is reduced to the conventional quantization strategy described hereinabove.

However, if channel gain variations occurred within the received frame, then $\Theta_{min} \neq \Theta_{max}$ and a larger value of Desired_RMS will be utilized, thus emphasizing the fade region as is indeed desirable.

Altogether, the method of the invention provides improved quantization for fading channels without increasing the quantization loss for static channels.

The difference $\Theta_{max} - \Theta_{min}$ can serve as an easily computable measure for the fade variability within the received frame, and in step 254 $F(\Theta_{min}, \Theta_{max})$ can be implemented simply by means of a look-up table having $\Theta_{max} - \Theta_{min}$ at its input and Desired_RMS_Fade at its output.

Different tables may be used when the receiver has to cope with different codes, as is the case for example in IS-95 Rate-set 2 situations where the code properties (puncturing level) may vary from frame to frame depending on the data rate.

The quantization method of the present invention, provides code-dependent channel-dependent quantization, which can be tuned to the specific codes and channel conditions by properly adjusting the

look-up table values, so that low quantization loss is achieved over a wide variety of practical scenarios.

According to another aspect of the invention, more complicated functionals can be used to detect the channel fading characteristic. An example for such a functional is given by $\Theta[n] \equiv |\hat{h}[n]|$ that should replace the functional in Equation 8.

This functional is more difficult to calculate but it provides better estimation of the fade variability. According to a further aspect of the invention, the fade duration is measured and incorporated in $F(\Theta_{\min}, \Theta_{\max})$.

In another preferred embodiment, the demodulator is replaced by the rake receiver. The above quantization procedure remains unchanged, except to the definitions of $\Theta[n]$ in Equation 8, that should now be:

$$\Theta[n] \equiv \sum_{k=1}^{F} \left|\mathrm{Re}al\{\hat{h}_k[n]\}\right| + \left|\mathrm{Im}ag\{\hat{h}_k[n]\}\right|$$

Equation 11

where F denotes the number of active fingers, and where $\hat{h}_k[n]$ denotes the channel tap estimator of the k'th finger.

In another preferred embodiment, the data block may be divided into sub-blocks of size N_1, N_2......N_k such that

$$N = \sum_{i=1}^{k} N_i$$

Then, the maximization and minimization in Equation 7 may be performed for each of K sub-blocks, yielding up-to K different values of Desired_RMS_Fade for a given data frame, K is a design parameter. In this situation, the quantizer should provide information, regarding the different gains used within the data block, to the decoder, thus enabling the decoder to compensate these gain variations during the decoding process.

Reference is now made to Fig. 3, which is a schematic illustration of a receiver, generally referenced 100, constructed and operative in accordance with a preferred embodiment of the present invention.

Receiver 100 includes a demodulator 102, a frame buffer 104, an analog to digital (A/D) converter 106, a decoder 108 and a channel processor 110. The frame buffer 104 is connected to the A/D converter 106 and to the demodulator 102. The A/D converter 106 is further connected to the channel processor 110 and to the decoder 108.

The receiver 100 receives a signal from an unknown dynamic channel. The demodulator 102 demodulates the received signal and stores the demodulated signal in the frame buffer 104. At the same time, the channel processor 110 analyzes the received signal, thereby detecting the fading characteristics thereof and provides them to the A/D converter 106.

The A/D converter 106 retrieves the demodulated signal and quantizes it according to the fading characteristics. For example, on the one hand, when the fading characteristics indicate that the signal was diminished by the fading channel, then, the A/D converter 106 enhances the demodulated signal before or during the quantization procedure. On the other hand, when the fading characteristics indicate a static (i.e. non fading) channel then, the A/D converter 106 follows the conventional quantization strategy.

Finally, the A/D converter 106 provides the quantized signal to the decoder 108, which in turn decodes it and provides a decoded signal at its output.

Reference is now made to Fig. 4, which is a schematic illustration of a method for operating the receiver 100 of Fig. 3.

In step 170, the receiver receives a portion of a signal from an unknown channel. The channel may impose either a diminishing or amplifying effect of the signal, thereby deforming it.

In step 172, the receiver stores the received portion either in the received format or in a demodulated format.

In step 174, the receiver analyzes the received signal, thereby detecting its channel characteristics.

In step 176, the receiver determines from the channel characteristics, if the channel through which the signal traveled, is problematic. If so, then the receiver proceeds to step 178. Otherwise, the receiver proceeds to step 180.

In step 178, the receiver estimates a correction action according to the detected channel characteristics. Then, the receiver proceeds to step 180.

In step 180, the receiver processes the received signal according to the estimated correction action. It will be noted that when the receiver determined that the channel is not problematic, then, the correction action is null.

It will be noted that the present invention can be implemented in many ways. For example, in accordance with a further embodiment of the present invention, there is provided a novel channel quantizer which replaces a conventional quantizer between the demodulator and the decoder.

Reference is now made to Fig. 6, which is a schematic illustration of a receiver, generally referenced 200, in which there is installed a quantizer, generally referenced 216, constructed and operative in accordance with a further preferred embodiment of the present invention. The quantizer 216 is connected between a demodulator 202

and a decoder 208. In the present example, the decoder 208 is a Viterbi decoder.

Quantizer 216 includes a channel estimator 210, a controller 212, a frame buffer 204 and a quantizing unit 206. The controller 212 is connected between the quantizing unit 206 and the channel estimator 210. The quantizing unit is also connected to the frame buffer 204.

The channel estimator 210 is further connected to the source of the received signal (e.g. an antenna - not shown) which is also fed into the demodulator 202. The frame buffer 204 is further connected to the demodulator 202. The quantizing unit 206 is further connected to the decoder 208.

The channel estimator 210 detects channel characteristics of a portion of the received signal and provides them to the controller 212. The controller 212 analyses these characteristics thereby determining a set of correction parameters. At the same time, the demodulator 202 demodulates the portion of the received signal and provides the demodulated signal to the quantizer channel dependent quantizer 216, where it is stored in the frame buffer 204.

When the quantizing unit 206 receives the set of correction parameters from the controller 212, it retrieves the respective demodulated signal from the frame buffer 204. Then, the quantizing unit 206 quantizes the demodulated signal according to the set of correction parameters and provides the quantized signal to the decoder 208.

According to another aspect of the present invention, the information regarding the channel characteristics is also used in the decoding stage.

Reference is now made to Fig. 7, which is a schematic illustration of a receiver, generally referenced 300, constructed and

operative in accordance with a further preferred embodiment of the present invention.

Receiver 300 includes a demodulator 302, a frame buffer 304, a quantizer 306, a decoder 308 and a channel tap estimator 312.

The frame buffer 304 is connected to the demodulator 302 and to the quantizer 306. The Viterbi decoder 308 is connected to the quantizer 306 and to the channel tap estimator 312.

The demodulator 302 and the channel tap estimator 312 receive a portion of a received signal which was transmitted via an unknown dynamic channel. The demodulator 302 demodulates the received signal and stores the demodulated signal in frame buffer 304. The channel tap estimator 312 analyses the received signal, produces a set of correction parameters and provides them to the quantizer 306 and to the decoder 308.

The quantizer 306 retrieves the demodulated signal from the frame buffer 304 and quantizes it according to the set of correction parameters received from the channel tap estimator 312, thereby producing a quantized signal. Then, the quantizer 306 provides the quantized signal to the decoder 308.

The decoder 308 decodes the quantized signal in view of the set of correction parameters received from the channel tap estimator 312.

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather the scope of the present invention is defined only by the claims which follow.

CLAIMS

1. Method for processing a received signal, the signal being received from a dynamically fading channel, the method comprising the steps of:

   detecting the fading characteristics of said fading channel; and

   determining a quantization correction command for at least one segment of said received signal.

2. The method according to claim 1, further comprising the step of quantizing said at least one segment according to said quantization correction command, thereby producing a quantized signal.

3. The method according to claim 2, further comprising the step of decoding said quantized signal.

4. The method according to claim 3, wherein said step of decoding said quantized signal is performed while taking into account said quantization correction command with respect to said at least one segment.

5. The method according to claim 1, further comprising the step of demodulating said received signal.

6. The method according to step 1, wherein said step of detecting comprises the sub-steps of:

   estimating the RMS of said received signal; and

   computing the minimal and maximal quantities of the samples of said received signal.

7. The method according to claim 1, wherein said step of determining comprises the sub-step of estimating a preferred RMS value.

8. The method according to claim 7, further comprising the step of normalizing said received signal according to said preferred RMS value.

9. The method according to claim 1, wherein said step of detecting comprises the following sub-steps:

estimating the RMS of said received signal, thereby producing an Estimated_RMS value, and

estimating channel tap values $\hat{h}[n]$ from said received signal.

10. The method according to claim 9, wherein said step of determining comprises the following sub-steps:

calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv |\mathrm{Re}al\{\hat{h}[n]\}| + |\mathrm{Im}ag\{\hat{h}[n]\}|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and

determining a desired_RMS_fade value from said $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

11. The method according to claim 9, further comprising the step of normalizing said samples.

12. The method according to claim 11, wherein said step of determining comprises the following sub-steps:

calculating Θ_{min} and Θ_{max} values, wherein $\Theta[n] \equiv |\mathrm{Re}\,al\{\hat{h}[n]\}| + |\mathrm{Im}\,ag\{\hat{h}[n]\}|$, $\Theta_{max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{min} \equiv Min_n\{\Theta[n]\}$, and

determining a desired_RMS_fade value from said Θ_{min}, Θ_{max}, and $\Theta[n]$ and

wherein said step of normalizing is performed according to the following expression:

$$\tilde{Y}[n] = \frac{Desired\_RMS\_Fade}{Estimated\_RMS} \cdot Y[n]$$

wherein $Y[n]$ denotes a pre-quantized value of a selected sample and $\tilde{Y}[n]$ denotes a normalized pre-quantized value of said selected sample.

13. The method according to either of claims 10 and 12, wherein said desired_RMS_fade value is determined from said Θ_{min}, Θ_{max}, and $\Theta[n]$ according to a look-up table having $\Theta_{max} - \Theta_{min}$ at its input and Desired_RMS_Fade at its output.

14. In a receiver which includes a signal reception unit, a demodulator and a decoder, the receiver receiving a signal from a dynamically fading channel, the demodulator demodulating said received signal thereby producing demodulated signal, a quantizing device comprising;

a channel fading detection unit, connected to said signal reception unit, for detecting the fading characteristics of said dynamically fading channel;

a processor, connected to said channel fading detection unit, for processing said fading characteristics, thereby producing a correction command for at least one segment of said received signal;

a quantizing unit connected to said processor, said demodulator and said decoder, for quantizing said demodulated signal, thereby producing a quantized signal;

wherein said quantizing unit also corrects said at least one segment according to said correction command; and

wherein said decoder decodes said quantized signal.

15. The quantizing device according to claim 14, wherein said processor provides said correction command to said decoder and said decoder decodes said quantized signal according to said correction command.

16. The quantizing device according to claim 15, wherein said processor determines said correction command by calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv |\mathrm{Re}\,al\{\hat{h}[n]\}| + |\mathrm{Im}\,ag\{\hat{h}[n]\}|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and subsequently determining a desired_RMS_fade value from said $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

17. The quantizing device according to claim 16, wherein said desired_RMS_fade value is determined from said $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$ according to a look-up table having $\Theta_{\max} - \Theta_{\min}$ at its input and Desired_RMS_Fade at its output.

18. In a receiver which includes a signal reception unit, a demodulator, a quantizing unit and a decoder, the receiver receiving a signal from a dynamically fading channel, the demodulator demodulating said received signal thereby producing demodulated signal, a fading compensation device comprising;

a channel fading detection unit, connected to said signal reception unit, for detecting the fading characteristics of said dynamically fading channel;

a processor, connected to said channel fading detection unit, for processing said fading characteristics, thereby producing a correction command for at least one segment of said received signal;

a correction unit, connected to said processor, said demodulator and said quantizing unit, for correcting the demodulated segment corresponding to said at least one segment according to said correction command, thereby producing a corrected segment,

wherein said correction unit replaces said demodulated segment with said corrected segment at the input of said quantizing unit.

19. The fading compensation device according to claim 18, wherein said processor determines said correction command by calculating $\Theta_{\min}$ and $\Theta_{\max}$ values, wherein $\Theta[n] \equiv \left|\mathrm{Re}\,al\{\hat{h}[n]\}\right| + \left|\mathrm{Im}\,ag\{\hat{h}[n]\}\right|$, $\Theta_{\max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{\min} \equiv Min_n\{\Theta[n]\}$, and subsequently determining a desired_RMS_fade value from said $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$.

20. The quantizing device according to claim 19, wherein said desired_RMS_fade value is determined from said $\Theta_{\min}$, $\Theta_{\max}$, and $\Theta[n]$ according to a look-up table having $\Theta_{\max} - \Theta_{\min}$ at its input and Desired_RMS_Fade at its output.

21. The fading compensation device, according to claim 18, wherein said processor is further connected to said decoder, thereby providing said correction command to said decoder for decoding the quantized representation of said corrected segment, with respect to said correction command.

22. A receiver comprising:

a signal reception unit, for receiving a signal from a dynamically fading channel;

a demodulator, connected to said signal reception unit, for demodulating said received signal, thereby producing a demodulated signal therefrom;

a quantizing processor, connected to said demodulator and to said signal reception unit, for analyzing said received signal and for quantizing said demodulated signal, thereby producing a quantized signal; and

a decoder, connected to said quantizing processor, for decoding said quantized signal,

wherein said quantizing processor normalizes said demodulated signal according to the estimated fading of said received signal.

23. The receiver according to claim 22, wherein said received signal is a DS-CDMA signal and wherein said demodulator is a rake receiver.

24. The receiver according to claim 23, wherein said quantizing processor analyzes said received signal by summing the channel taps of selected fingers.

25. The receiver according to claim 22, wherein said decoder is a Viterbi decoder.

26. The receiver according to claim 22 or 25, wherein said quantizing processor analyzes said received signal by calculating Θ_{min} and Θ_{max} values, wherein $\Theta[n] \equiv |\mathrm{Re}al\{\hat{h}[n]\}| + |\mathrm{Im}ag\{\hat{h}[n]\}|$, $\Theta_{max} \equiv Max_n\{\Theta[n]\}$, and $\Theta_{min} \equiv Min_n\{\Theta[n]\}$, and subsequently determining a desired_RMS_fade value from said Θ_{min} , Θ_{max}, and $\Theta[n]$.

27. The receiver according to claim 26, wherein said quantizing processor calculates said desired_RMS_fade value is determined from said Θ_{min} , Θ_{max}, and $\Theta[n]$ according to a look-up table having $\Theta_{max} - \Theta_{min}$ at its input and Desired_RMS_Fade at its output.

ABSTRACT

A receiver including a signal reception unit, for receiving a signal from a dynamically fading channel, a demodulator, connected to the signal reception unit, for demodulating the received signal, thereby producing a demodulated signal therefrom, a quantizing processor, connected to the demodulator and to the signal reception unit, for analyzing the received signal and for quantizing the demodulated signal, thereby producing a quantized signal, and a decoder, connected to the quantizing processor, for decoding the quantized signal, wherein the quantizing processor normalizes the demodulated signal according to the estimated fading of the received signal.

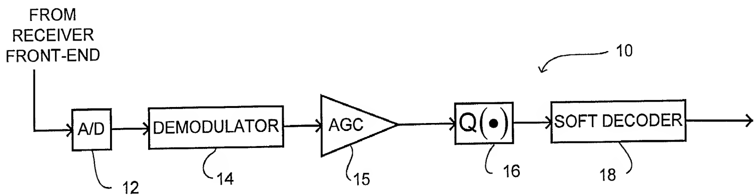


FIG. 1
PRIOR ART

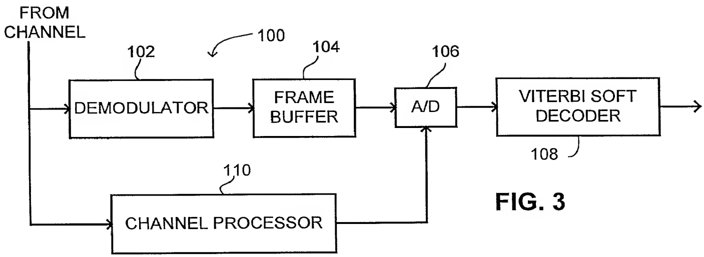

FROM CHANNEL
100
102
104
106
DEMODULATOR
FRAME BUFFER
A/D
VITERBI SOFT DECODER
108
110
CHANNEL PROCESSOR

FIG. 3

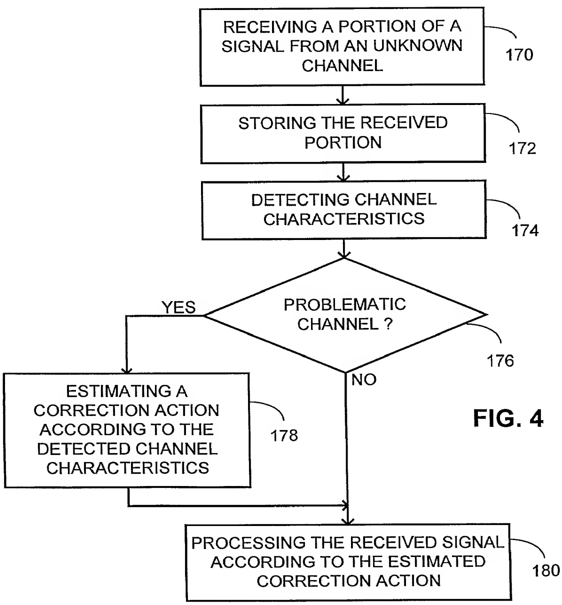

RECEIVING A PORTION OF A SIGNAL FROM AN UNKNOWN CHANNEL
170
STORING THE RECEIVED PORTION
172
DETECTING CHANNEL CHARACTERISTICS
174
PROBLEMATIC CHANNEL ?
YES
NO
176
ESTIMATING A CORRECTION ACTION ACCORDING TO THE DETECTED CHANNEL CHARACTERISTICS
178
PROCESSING THE RECEIVED SIGNAL ACCORDING TO THE ESTIMATED CORRECTION ACTION
180

FIG. 4

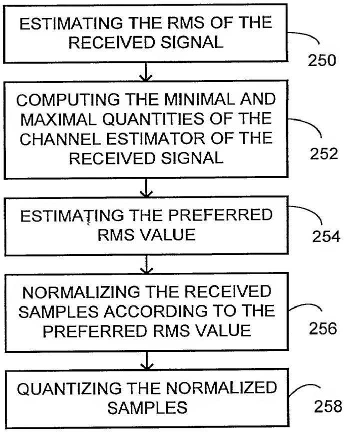

ESTIMATING THE RMS OF THE RECEIVED SIGNAL
250
COMPUTING THE MINIMAL AND MAXIMAL QUANTITIES OF THE CHANNEL ESTIMATOR OF THE RECEIVED SIGNAL
252
ESTIMATING THE PREFERRED RMS VALUE
254
NORMALIZING THE RECEIVED SAMPLES ACCORDING TO THE PREFERRED RMS VALUE
256
QUANTIZING THE NORMALIZED SAMPLES
258

FIG. 5

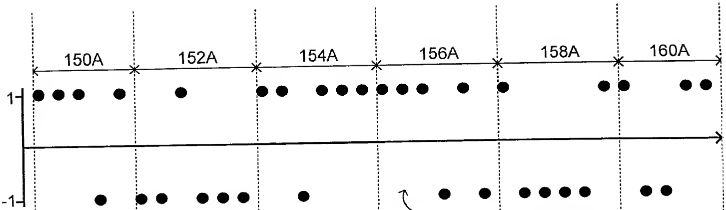


FIG. 2A

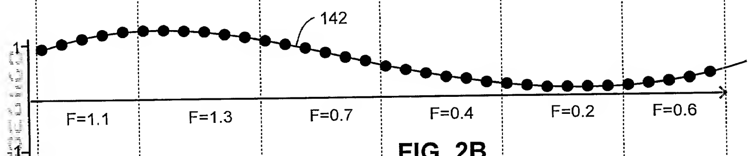


FIG. 2B

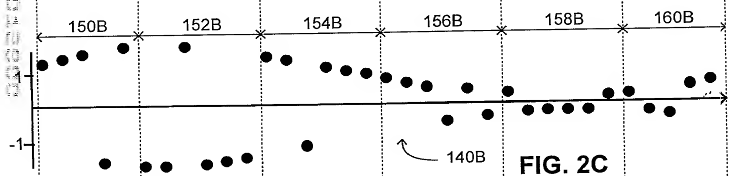


FIG. 2C

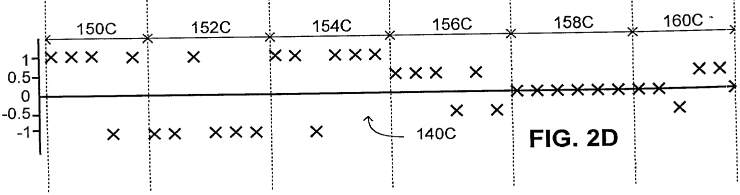
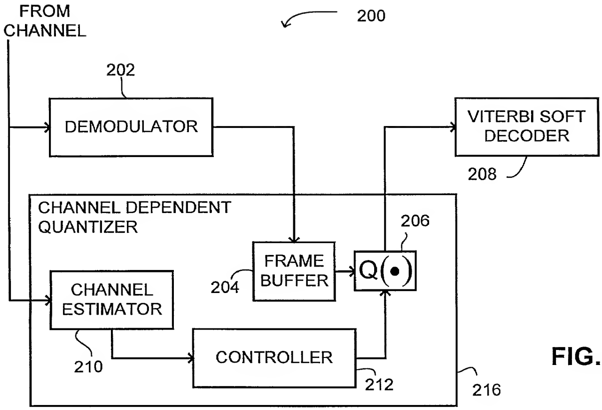
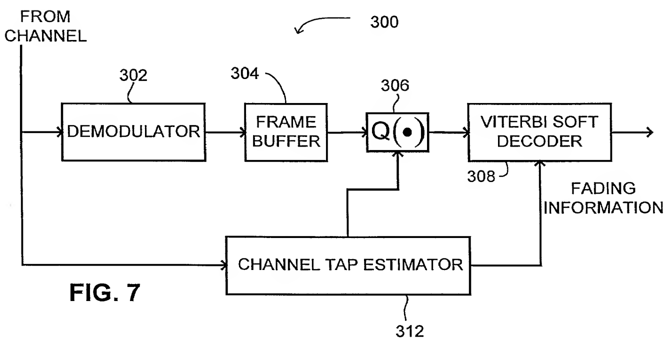


FIG. 2D



FROM CHANNEL
200
202
DEMODULATOR
VITERBI SOFT DECODER
208
CHANNEL DEPENDENT QUANTIZER
206
FRAME BUFFER
Q(•)
204
CHANNEL ESTIMATOR
CONTROLLER
210
212
216

FIG. 6



FROM CHANNEL
300
302
304
306
DEMODULATOR
FRAME BUFFER
Q(•)
VITERBI SOFT DECODER
308
FADING INFORMATION
CHANNEL TAP ESTIMATOR
312

FIG. 7

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below adjacent to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of subject matter (process, machine, manufacture, or composition of matter, or an improvement thereof) that is claimed and for which a patent is solicited by way of the application entitled

METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS

which (check)

[ ] is attached hereto.
[ ] and is amended by the Preliminary Amendment attached hereto.
[X] was filed on June 15, 1998 as Application Serial No. 09/103,683
[ ] and was amended on ____________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I further state that I do not know and do not believe that the same was ever known or used in the United States of America before my or our invention thereof or patented or described in any printed publication in any country before my or our invention thereof, or more than one year prior to this application, or in public use or on sale in the United States of America more than one year prior to this application, that the Invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

(Number)	(Country)	(Day/MM/Year filed)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as any subject matter of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

N/A
Serial No.   Filing Date   Status (Patented/pending/abandoned)

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith:

Gordon D. Coplein #19,165, William F. Dudine Jr. #20,569, Michael J. Sweedler #19,937, S. Peter Ludwig # 25,351, Paul Fields #20,298, Harold E. Wurst #22,183, Joseph B. Lerch #26,936, Melvin C. Garner #26,272, Ethan Horwitz #27,646, Beverly B. Goodwin #28,417, Adda C. Gogoris #29,714, Martin E. Goldstein #20,869, Bert J. Lewen #19,407, Henry Sternberg # 22,408, Robert A. Green #28,301, Peter C. Schechter #31,662, Robert Schaffer #31,194, David R. Francescani #25,159, Robert C. Sullivan, Jr. #30,499, Ira J. Levy #35,587, Joseph R. Robinson #33,448, all of the firm of Darby & Darby P.C., 805 Third Avenue, New York, New York 10022

Attached as part of this declaration and power of attorney is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE TO DIRECT TELEPHONE CALLS TO:

DARBY & DARBY P.C.   S. PETER LUDWIG
805 THIRD AVENUE
NEW YORK, NEW YORK 10022   (212) 527-7700

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first inventor: Daniel YELLIN

Inventor's signature: ________   Date: 09/14/98

Residence: 13 Erez Street, Karmei Yosef 99797, Israel

Post Office Address: Same   Citizenship Israeli

p-1500\1592\us\declr (lf)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
DECLARATION FOR PATENT APPLICATION

INVENTOR(S) : **YELLIN, Daniel**

TITLE : **METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS**

DOCKET NO. :

TO THE HONORABLE COMMISSIONER OF PATENTS AND TRADEMARKS:

As a below named inventor, I hereby declare that:

This declaration is of the following type: (check one applicable item below)

☒ original
☐ design
☐ supplemental

NOTE: *If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application do not check next item; check appropriate one of last three items.*

☐ national stage of PCT

And is a

☐ divisional
☒ continuation
☐ continuation-in-part (CIP)

of U.S. Patent Application 09/103,683.

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **METHOD AND DEVICE FOR QUANTIZING THE INPUT TO SOFT DECODERS**, the specification of which is attached hereto unless the following is checked:

☐ was filed on as United States Application Number or PCT International Application Number , and was amended on ____________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 (see last page attached hereto).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a) - (d) or 265(b) of any foreign application(s) for patent or inventor's certificate or 365(a) of any PCT international application which designates at least one country other than the United States of America, listed below and have also identified below any foreign application for patents or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications: Priority Claimed:

(Number)	(Country)	(Day/Month, Year Filed)	☐ Yes	☐ No

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

(Application No.)	(Filing Date)	(Status - patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the National or PCT international filing date of this application.

09/103,683	**15 June 1998**	**pending**
(Application No.)	(Filing Date)	(Status - patented, pending, abandoned)
(Application No.)	(Filing Date)	(Status - patented, pending, abandoned)

As the inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the U.S. Patent and Trademark Office connected therewith. Name and registration number are listed below.

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JEROME R. SMITH JR.	35,684
MARK S. COHEN	42,425
DANIEL J. SWIRSKY	45,148
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JOHN L. WELSH	33,621
HOWARD N. FLAXMAN	34,595

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(703) 920-1122

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor:

YELLIN, Daniel
Residence : **71 Hertzel Street, Ra'anana 43353, Israel**
Citizenship : **Israeli**
Post Office Address: **Same**

Date: ________________ Signature: ______________________________

Full name of second joint inventor, if any:

____
Residence : ________________
Citizenship : ________________
Post Office Address: ______________________________

Date: ________________ Signature: ______________________________

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim is issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim;
or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventory may comply with this section by disclosing information to the attorney, agent, or inventor.